Mitigating Uncertainty in the Hydrodynamic Modelling of Oscillating Water Column Wave Energy Converters

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Background

An ocean wave is energy in motion. A wave energy converter (WEC) is a machine that harnesses this energy and generates renewable electricity. This clean, emission free energy solution makes environmental sense, and can provide sufficient wave-powered generation of electricity to meet Australia's current demand, but fulfilling the potential of wave energy requires overcoming technical and economic barriers.

This industry-targeted research aims to remove technical barriers faced in the research and development phase of wave energy technology.

A systemic suite of physical experiments in hydrodynamic testing facilities will provide data for developing procedures for (i) scaling up small-scale results, particularly relevant for the oscillating water column (OWC) WEC (Figure 1), one of the most established and versatile concepts in wave energy, and (ii) experimental uncertainty analysis to increase the quality and reliability of experimental data. We will provide unprecedented calibration and validation of these procedures using data from a full-scale ocean deployment of industry partner Wave Swell Energy's pre-commercial WEC, in King Island near Tasmania, planned for 2018 (Figure 2).

More reliable design data and a better understanding of uncertainties in WEC experiments will improve the predictions and performance of full-scale WECs. Less uncertainty in performance predictions of a technology will enable project developers to make informed decisions on demonstrations and deployments in the ocean, crucial for the commercial development of an industry that is aiming to accelerate the sustainable energy future.

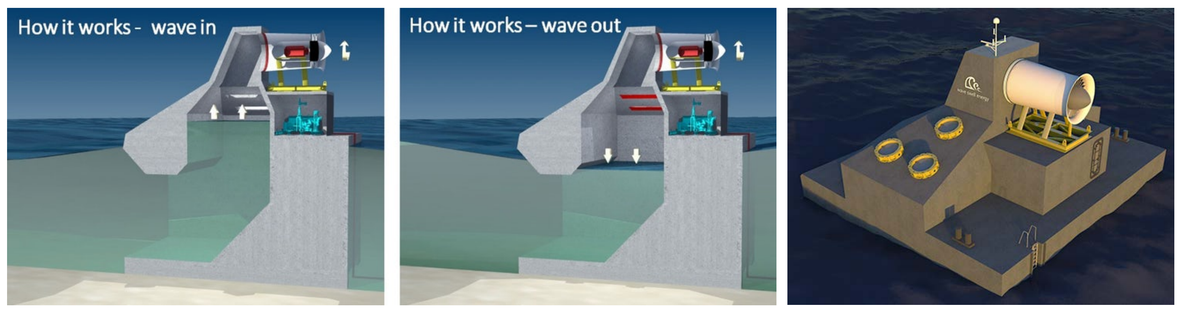


Figure 1. An oscillating water column wave energy converter: How it works & a full-scale device

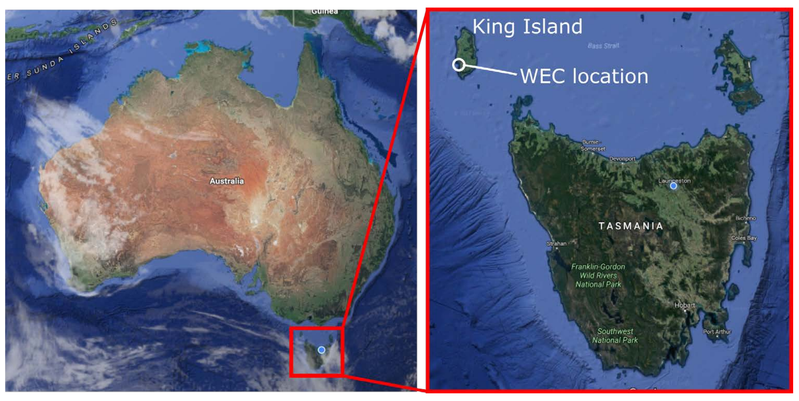
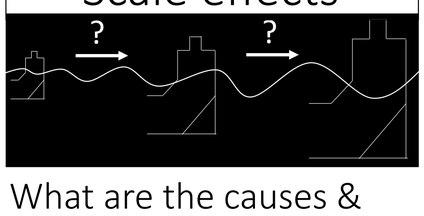


Figure 2. The proposed location of the King Island wave energy project

Overview

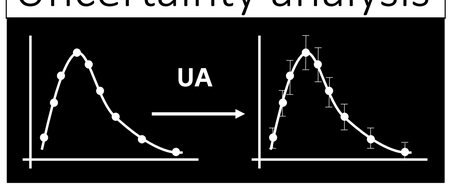
What is best practice for hydrodynamic modelling of OWCs?

Scale effects



What are the causes & effects of scale effects?

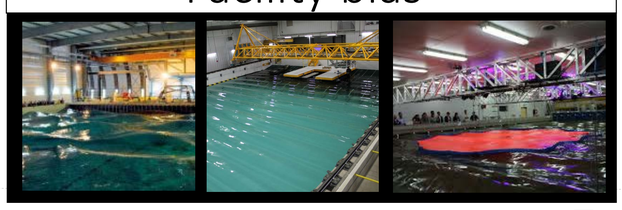
Uncertainty analysis



What is required for an uncertainty analysis?

PHYSICAL SCALE EXPERIMENTS

Facility bias



How do facility biases influence OWC WEC model test results?

Future best practice for testing & developing OWC WECs

Figure 3. PhD research project in a nutshell

Methodology

This physical experimental based PhD project will be carried out in three stages:

1. Review of guidelines for WEC model test experiments
2. Experimental work and procedure development
3. Research collation and recommendations

The second stage is the major part of the project. It is further broken into two primary sub-stages:

1. Suite of physical scale model test experiments that address experimental uncertainty: small and medium/large scale testing of an OWC concept in various wave tank facilities.
2. Expanding the extrapolation procedure for model-to-full-scale OWC WECs: using full-scale data from a 1MW device. This is shown graphically in Figure 4.

Figure 4. Stage 2, Part 2: Using full-scale data to validation and calibrate model-scale extrapolation procedures

Completed Work

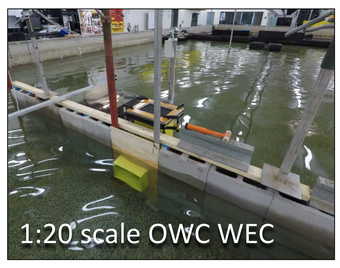
Review of guidelines for WEC model test experiments

We have completed a comprehensive review of available guidelines, and are working on a journal paper for submission to Q1 journal: *Renewable & Sustainable Energy Reviews.*

Experimental investigations

We have completed two experimental investigations.

- The first amounted to a conference paper: "Experimental Uncertainty Analysis of an OWC Wave Energy Converter" presented at the European Wave and Tidal Energy Conference in Cork, Ireland, Sept 2017. Following is a brief overview and some results of this work.



AIM: Practical example of an uncertainty analysis (UA) relevant to WEC model test experiments
METHOD: Measurement UA, including Type A/B, and propagation of uncertainty for power.
RESULTS:

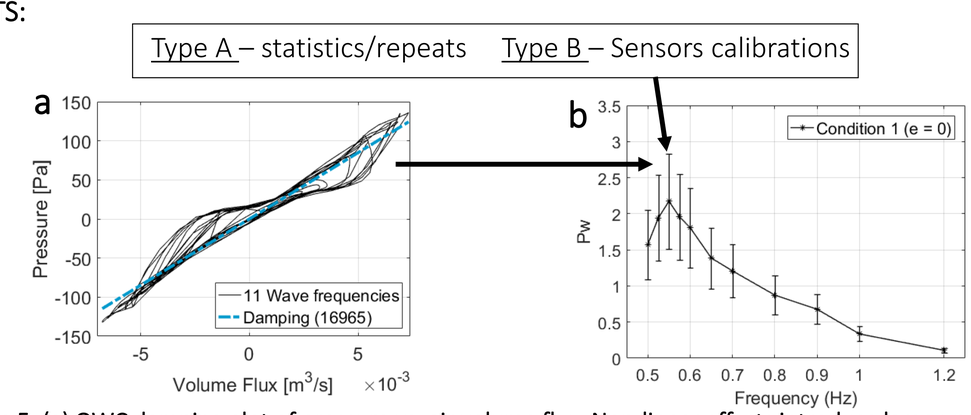
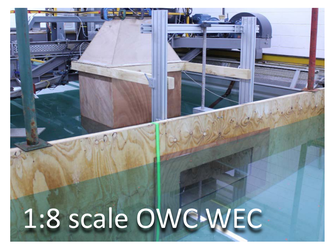


Figure 5. (a) OWC damping plot of pressure vs. air volume flux. Non-linear effects introduce large uncertainty. (b) OWC power relative to incident wave power across a range of wave frequencies. Plot (a) + Type A + Type B uncertainties produce a ± 30% uncertainty in OWC power

CONCLUSIONS: Necessary to carry out UA on all WEC model test experiments: large uncertainty in the hydrodynamic modelling of WECs and power take-off (PTO) system. Type B dominant type.

- The second experimental investigation involved testing the same OWC WEC configuration as the first experiment, but at a larger scale to investigation scale effects. We are currently processing and analysing these results. We aim to publish these results in a conference paper, and use them as preliminary work towards a comprehensive study into scale effects of OWCs – submitting to Q1 journal: *Renewable Energy*.



Future Work

- Finish and submit journal publication of review of guidelines for WEC model test experiments
- Organise large-scale experiments in an other hydrodynamic test facilities (France, Japan, USA)
- Work with Wave Swell Energy to equip their full-scale WEC and incident wave field with instrumentation in order to compare ocean test data with model-scale data.
- Develop uncertainty analysis procedures for WECs, including pre-test, test, and post-test.
- Develop procedure for extrapolating OWC WEC model test results to full-scale
- Provide recommendations for future best practice in WEC model test experiments

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